

# An Intelligent Systems Architecture for Manufacturing

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## Abstract

The Intelligent Systems Architecture for Manufacturing (ISAM) is a reference model architecture for intelligent manufacturing systems. It is intended to provide a theoretical framework for the development of standards and performance measures for intelligent manufacturing systems. It also intended to provide engineering guidelines for the design and implementation of intelligent control systems for a wide variety of manufacturing applications.

ISAM consists of a hierarchically layered set of intelligent processing nodes organized as a nested series of control loops. In each node, tasks are decomposed, plans are generated, world models are maintained, feedback from sensors is processed, and control loops are closed. In each layer, nodes have a characteristic span of control, with a characteristic planning horizon, and corresponding level of detail in space and time. Nodes at the higher levels deal with corporate and production management, while nodes at lower levels deal with machine coordination and process control. ISAM integrates and distributes deliberative planning and reactive control functions throughout the entire hierarchical architecture, at all levels, with all spatial and temporal scales.

## Introduction

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The ISAM model addresses the manufacturing enterprise at a number of levels of abstraction.

1. At the highest level of abstraction, ISAM provides a conceptual framework for viewing the entire manufacturing enterprise as an intelligent system consisting of machines, processes, tools, facilities, computers, software, and human

beings operating, over time, on materials to produce products.

2. At a lower level of abstraction, ISAM provides a reference model architecture to support the development of standards and performance measures, and the design manufacturing systems and software.

3. At a still lower level of abstraction, ISAM is intended to provide engineering guidelines to implement specific instances of manufacturing systems such as machining and inspection systems.

## I. ISAM as a conceptual framework

The ISAM conceptual framework spans the entire range of manufacturing operations, from those that take place over time periods of microseconds and distances of microns to those that take place over time periods of years and distances of many kilometers. The ISAM model is intended to allow for the representation of activities that range from detailed dynamic analysis of a single actuator in a single machine to the combined activity of thousands of machines and human beings in hundreds of plants comprising the operations of a multinational corporation.

To span this wide range of activities, ISAM adopts a hierarchical layering with different range and resolution in time and space at each level. This permits the definition of functional entities at each level within the enterprise such that each entity can view its particular responsibilities and priorities at a level of spatial and temporal resolution that is understandable and manageable to itself. At any level within the hierarchy, functional entities receive goals and priorities from above and observe situations in the environment below. In each functional entity at each level, there are decisions to be made, plans to be formulated, and actions to be taken that affect peers and subordinates at levels below. Information must be processed, situations analyzed, and status reported to peers and supervisors above. Each functional entity needs access to a model of the world that enables intelligent decision making, planning, analysis, and reporting activity to be carried out despite the uncertainties and unwanted signals that exist in